© 2017 IJEDR | Volume 5, Issue 4 | ISSN: 2321-9939

BLDC Motor Control Mechanism with Hall Sensors using Programmable System on Chip

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***Abstract*— There are various types of a motor that fits a wide variety of applications. The Brushless DC (BLDC) motor is the ideal choice for applications that require better heat dissipation, silent operation, compact form, reliability, low maintenance and high efficiency. This motor provides a large amount of a torque. This motor is a synchronous motor. The brushed motor uses brushes for commutation. BLDC motors do not use brushes. They are electronically commutated. BLDC motors have a number of benefits over other motors. In this project, we execute the possibility of brushless DC motor control by utilizing Hall Effect sensors and PWM technique by using the Programmable System on Chip (PSoC) device. In this project, this motor is controlled by using project sensors and inverter setup. All control mechanism is planned using Programmable System on Chip (PSoC) platform. Schematic of this control mechanism has drawn using PSoC Creator firmware. There is no any physical contact for commutation between rotor and stator. To execute this succession, it is critical to know the rotor position. The easiest path is to use rotor position sensors. The sensors can be optical, Hall or magneto-resistance impact based (magnetic), or inductive. The Hall sensor is chosen in many applications for its high precision and ease. We have implemented control mechanism by recognizing sensor output of Hall Effect sensors.**

***Index Terms*— PSoC, BLDC motor, sensing output of Hall Effect sensor, PWM method, direction control, speed control**

I. INTRODUCTION

In today's market there are different economic constraints. Electrical systems are available in new standards. New generations of equipments are higher performance as compare to old system. So these improvements reduce time. Its decreasing system cost of production. BLDC motors are very popular in many applications. BLDC motor is beneficial as compared to brush DC motor because of BLDC motor uses an electric commutator. Electrical commutator is used for replacement of a mechanical commutator. It's making it more reliable than the brushed DC motor.

In market BLDC motors comes in different phases such as phase having one winding, phase having two winding and phase having three configurations. According to this, number of windings of the stator coil has an equivalent number for each phase. All of those 3-phase motors are the for most common and wide used, For developing the application of BLDC motor control there is need of speed control, over current protection and position control, for that purpose we use PSoC device will be easy platform to implement control mechanism. A BLDC motor accomplishes commutation electronically using rotor position feedback.

BLDC motor control using PSoC unit works has two sections:

[1] **Analog Section: -** In analog section we will develop the control circuit which controls the motor operation. Also this circuit will receive the sensing signal from motor and control.

[2] Firmware: - In this part we will include software which required controlling various operations, also it helps program with various parameters.

II. SYSTEM MODEL

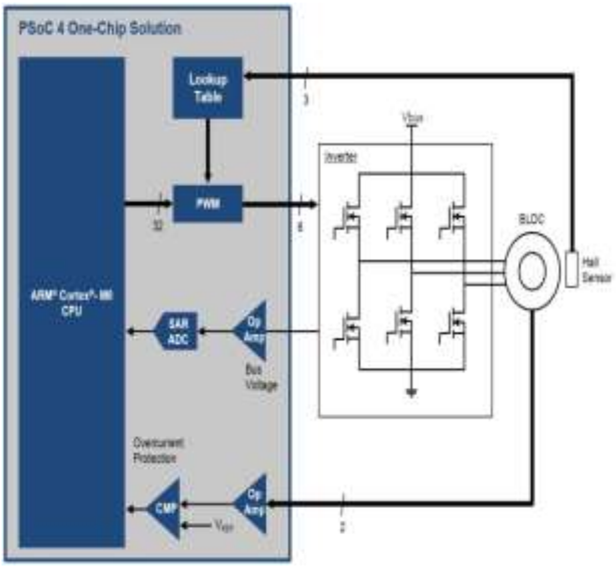

Fig1: PSoC 4 On Chip Solution Block diagram

The input management signals to the PSoC four devices are as follows.
Speed command: Analog input pins are used for to measurement of the voltage across potentiometer afterward it set the required speed of rotation.

Motor current observation: A once measurement of the speed rotation analog input pin detects and cuts off the power device driver to guard the motor. This step is happens once an over current condition is detected.

Hall sensing elements: Within the hall sensor 3 digital input pins connected .These sensing element inputs give the position of the motor and area accustomed management the commutation by varying the PWM output signals to the power driver.

Start/stop control: Digital input connected to a switch to begin and stop motor rotation.

III. RELATED WORK

Different types System diagram consists of following hardware parts:
1. BLDC Motor (with sensing element)
2. Inverter
3. PSoC development kit of operators

A. BLDC Motor (with sensing element)

BLDC motors have a number of advantages. By using Hall Effect sensors or encoder, it's become more accurate. It's used for commutation. It doesn't have brushes. They require less maintenance.
The brushed motor has many disadvantages due to speed/torque tradeoff. BLDC having advantages include high output power, small in size, heat dissipation is good, speed ranges are high, and noise free (mechanical and electrical) operation.

Fig2: 24 V BLDC Motor with 4000 rpm

B. Inverter

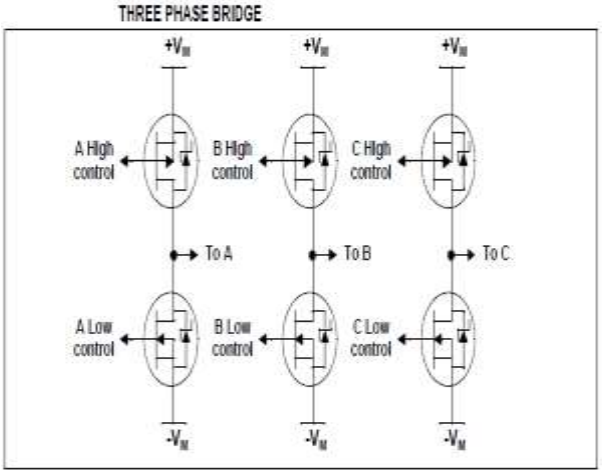

Fig3: H Bridge Inverter

This is 3 Phase inverter used in this project. In 3-phase inverter converts a DC input into a 3-phase AC output. Inverter consists three arms that are normally delayed by an angle of 120° so as to generate a 3-phase AC supply.

C. PSoC development kit of operators

In this project, we use PSoC 4 Kit devices with Arduino compatible headers where we can connect another shield as per our application. PSoC 4 kits provide a microcontroller core, flash program memory, SRAM data memory, and configurable analog and digital peripheral blocks in a single chip. Since **configurable-analog-module is** one of the major advantages of this PSoC device.The PSoC 4 Kit consists of the following blocks:

1) Power supply
2) Arduino compatible headers
3) Digilent Pmod compatible headers
4) PSoC 5LP GPIO header
5) Cap Sense slider
6) Push buttons

Fig4: PSoC 4 development board

IV. COMMUTATION PROCESS

In Commutation, rotation field is created. It's vital to stay the angle is made between stator coil which having different pole pairs and rotor flux generated in permanent magnet near to 90° for a BLDC motor to work keenly. A total of six stator coil flux vectors are generated by using Six step management of PWM output signal to turn on power devices. The stationary field which having coil flux vector should be modified to an explicit as a position of the rotor. A Hall sensor uses the position of a rotor which can sense by hall sensor. The Hall sensors generate 3 signals. These 3 signals are distributed in six states. These six state decides which power device (power transistor) is evoked. There are two transistors are evoked at a time. It gives positive supply to one phase, negative supply to the second phase and zero supply to last one. These orders are given in sequence table for clockwise and anticlockwise.

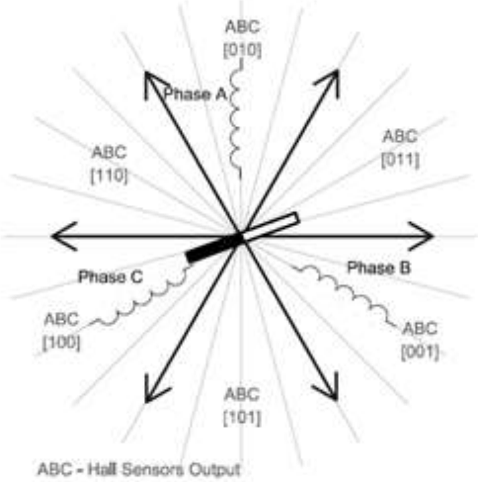

Fig5: Stator Coil Flux Vector

Order gives in table for clockwise rotation:

Order (sequence)	Hall Sensor Input			Phase Current(DC)		
	A	B	C	A	B	C
1	0	0	1	+Ve	Off	-Ve
2	0	0	0	+Ve	-Ve	Off
3	1	0	0	Off	-Ve	+Ve
4	1	1	0	-Ve	Off	+Ve
5	1	1	1	-Ve	+Ve	Off
6	0	1	1	Off	+Ve	-Ve

Table 1: Order for motor rotating in the clockwise direction

Order for the motor rotating in anti clockwise direction when viewed from non-driving end:

Order (sequence)	Hall Sensor Input			Phase Current(DC)		
	A	B	C	A	B	C
1	0	1	1	Off	-Ve	+Ve
2	1	1	1	+Ve	-Ve	Off
3	1	1	0	+Ve	Off	-Ve
4	1	0	0	-Ve	+Ve	-Ve
5	0	0	0	-Ve	+Ve	Off
6	0	0	1	-Ve	Off	+Ve

Table 2: Order for rotating the motor in anticlockwise direction when viewed from non-driving end

V. FIRMWARE PART

In the code, there is three Hall detector signals are imported by pins "H1," "H2," and "H3". This detector passes the signal "Lut_Cmut" that is generating the outputs to the PWM signal to the motor windings in keeping with the Hall signals and its internal commutation table. "PWM_Drive" generates the period of time duty cycle to follow the user's revolutions per minute request.

PI controller is also used in this project. In control loop, output of the error signal gets multiplied by the proportional and integral constant.

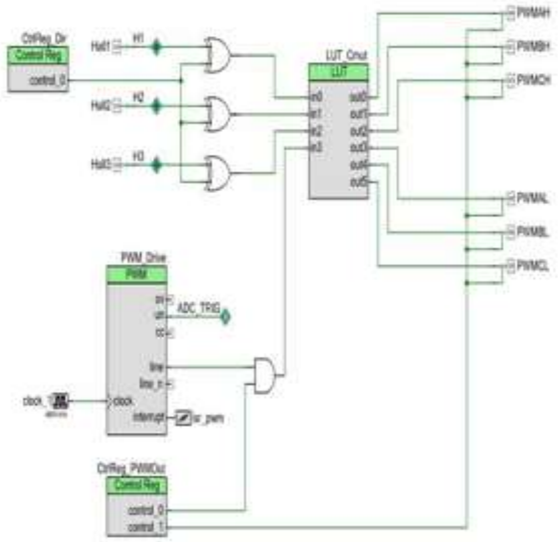

Fig6: Schematic for motor commutation

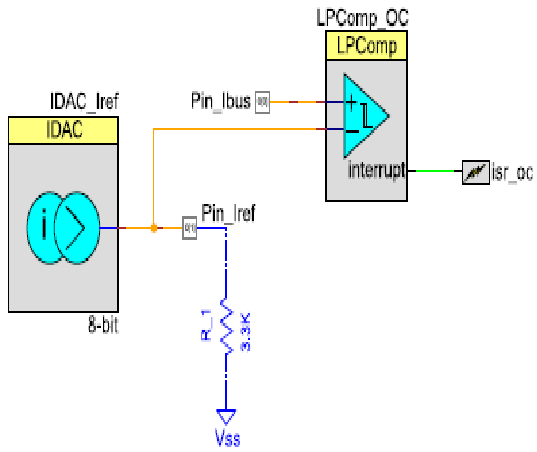

Fig7: Schematic for excess current protection

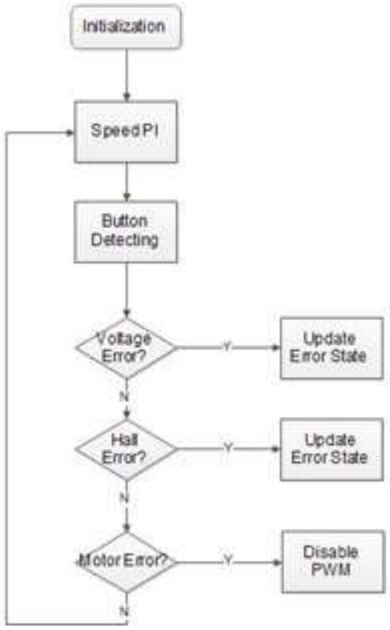

Fig8: Flowchart for program logic.

VI. IMPLEMENTATION AND RESULTS

By using potentiometer of driver circuit we can vary the motor. The motor is run without any error that means current coming through back emf and input is not excess current.

I have recorded the graph of hall sensors and PWM outputs:

Fig9: hall sensors output

Fig10: PWM output

VII. ACKNOWLEDGEMENT

I am immensely grateful to Dr. A. A. Shinde and Mr. Abhay who provided support and expertise that greatly assisted the re-search.

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